REMARKS

Applicant concurrently files herewith an excess claim fee for (3) three dependent claims.

Claims 1-3, 5-13, 15-22, 25-34, and 38-50 are pending in the application. This Amendment currently amends claims 1-3, 5, 6-13, 15, 16, 18-22, 26-30, and 32-34, cancels without prejudice or disclaimer claims 4 and 14, and adds new claims 41-50. No new matter is added to currently amended claims 1-3, 5, 6-13, 15, 16, 18-22, 26-30, and 32-34 or to new claims 41-50.

Claims 1-3, 5, 6-13, 15, 16, 18-22, 26-30, and 32-34 are currently amended to merely clarify the subject matter of the claims and in no way narrow the scope of the claims in order to overcome the prior art or for any other statutory purpose of patentability.

Notwithstanding any current claim amendments of the current Amendment or those amendments that may be made later during prosecution, Applicants' intent is to encompass equivalents of all claim elements. Reconsideration in view of the foregoing amendments and the following remarks is respectfully requested.

Claims 12-20 and 22 stand rejected under 35 U.S.C. §112, second paragraph.

Claims 1-3, 8, 10, 21, 26, 27, 32, 34, 38, and 40 stand rejected under 35 U.S.C. §103(a) as obvious over U.S. Patent No. 6,252,254 B1 to Soules et al. (hereinafter, Soules) in view of JP 11-177141 to Sendai et al. (hereinafter, JP '141). Claims 4-7, 9, 22 (insofar as definite) and 28-33 stand rejected under 35 U.S.C. §103(a) as unpatentable over Soules and JP '141 as applied to the claims above, and further in view of U.S. Patent No. 5,847,507 to Butterworth et al. (hereinafter, Butterworth). Claims 11-13, 18, 20 and 39 stand rejected under 35 U.S.C. §103(a) as unpatentable over Soules and JP '141 as applied to the claims above, and further in view of U.S. Patent No. 6,153,123 to Hampden-Smith et al. (hereinafter, Hampden-Smith). Claims 14-17 and 19 stand rejected under 35 U.S.C. §103(a) as unpatentable over Soules, JP '141, and Hampden-Smith as applied to claims 11-13, 18, 20, and 39 above, and further in view of Butterworth.

These rejections are respectfully traversed in view of the following discussion.

THE CLAIMED INVENTION

The claimed invention, as described in claim 1, is directed to *inter alia* a light-emitting apparatus that comprises a primary light source including a GaN semiconductor light-emitting device that emits light of a wavelength of 380 nm to 500 nm, the GaN semiconductor light-emitting device including a single reflective layer disposed on a surface of a substrate on which no light-emitting layer is formed, and a secondary light source including a fluorescent material that comprises at least one of ZnS:Cu, Au, Al; ZnS:Cu, Al; ZnS:Cu and Y_2O_2S:Ce, in which the fluorescent material absorbs light of a first wavelength, emitted by the primary light source, and emits light of a second wavelength, which is greater than the first wavelength.

The claimed invention, as described in claim 11, is directed to a light-emitting apparatus that comprises a primary light source including a GaN semiconductor light-emitting device that emits light of a wavelength of 380 nm to 500 nm, the GaN semiconductor light-emitting device including a single reflective layer disposed on a surface of a substrate on which no semiconductor layer is formed, and a secondary light source including a fluorescent material that comprises at least one of ZnS:Eu and Y2O2S:Ce, in which the fluorescent material absorbs light of a first wavelength, emitted by the primary light source, and emits light of a second wavelength, which is greater than the first wavelength.

The claimed invention, as described in claim 21, is directed to a light-emitting apparatus that comprises a first light source including a GaN semiconductor light-emitting device that emits blue light, the GaN semiconductor light-emitting device including a single reflective layer disposed on a surface of a substrate on which no semiconductor layer is formed, a second light source including a first fluorescent material that absorbs light emitted by the first light source and emits green light, and a third light source that emits red light, in which the blue light emitted by the first light source, the green light emitted by the second light source, and the red light emitted by the third light source are mixed together to thereby generate white light.

An exemplary aspect of the present invention provides a single reflective layer, included in the GaN semiconductor light-emitting device, that yields a directionality to light emitted from the light-emitting apparatus along its optical axis, so that, emitted light may be extracted from the entire surface of the substrate under the GaN semiconductor light-emitting

device.

Another exemplary aspect of the present invention allows the totality of light emitted from the light-emitting apparatus to be whiter than that of the blue-green light emitted by the GaN semiconductor light-emitting device because some of the blue-green light emitted by the GaN semiconductor light-emitting device is absorbed by a flourescent material, which emits fluorescent light of a longer wavelength.

II. THE PRIOR ART REJECTIONS

A. The Soules Reference

Fig. 1 of Soules discloses a phosphor coated LED or light-emitting device 10 having a blue-emitting LED 12 covered with a phosphor containing layer or covering 14 and a clear polymer lens 16 (col. 3, lines 45-49). Fig. 2 shows a phosphor-coated LED or light-emitting device 10 having a blue-emitting LED 12 covered with a phosphor-containing layer or covering 15, and a clear polymer lens 16 molded over layer 15 (col. 3, lines 49-53).

According to one example of Soules' invention, a combination of two blue-excited phosphors (excited by the blue emission from LED 12), one emitting in the green and one emitting in the red, is used in place of the yellow emitting yttrium aluminum garnet (col. 4, lines 1-5).

Soules discloses that one example of a phosphor composition comprises at least one of the following green-emitting phosphors: YBO_3:Ce, Tb; $BaMgAl_{10}O_{17}$:Eu, Mn; and $(Sr,Ca,Ba)(Al,Ga)_2S_4$:Eu; in combination with at least one of the following red-emitting phosphors: Y_2O_2S:Eu, Bi; YVO_4:Eu, Bi; SrS:Eu; SrY_2S_4:Eu; $CaLa_2S_4$:Ce; and (Ca,Sr)S:Eu (col. 4, lines 25-31).

Claim 1 recites at least the features of "said GaN semiconductor light-emitting device including a single reflective layer disposed on a surface of a substrate on which no light-emitting layer is formed; and a secondary light source including a fluorescent material that comprises at least one of ZnS:Cu, Au, Al; ZnS:Cu, Al; and ZnS:Cu."

Nowhere does Soules teach or suggest "said GaN semiconductor light-emitting device including a single reflective layer disposed on a surface of a substrate on which no semiconductor layer is formed," as recited in claim 1. The light emitted from the light-emitting apparatus of Soules is emitted in all directions. Whereas, the GaN semiconductor

light-emitting device, which includes a single reflective layer disposed on a surface of a substrate on which no light-emitting layer is formed, enhances the directionality of the light emitted from the apparatus along a preferred direction of the optical axis of the apparatus that is perpendicular to the bottom surface of the recessed portion.

Furthermore, nowhere does Soules teach or suggest "a fluorescent material that comprises at least one of ZnS:Cu, Au, Al; ZnS:Cu, Al; and ZnS:Cu," as recited in claim 1. Instead, Soules discloses the following green-emitting phosphors: YBO_3:Ce, Tb; $BaMgAl_{10}O_{17}$:Eu, Mn; and $(Sr,Ca,Ba)(Al,Ga)_2S_4$:Eu.

Claim 21 recites at least the features of "said GaN semiconductor light-emitting device including a single reflective layer disposed on a surface of a substrate on which no light-emitting layer is formed."

For at least those reasons discussed above in regard to claim 1, nowhere does Soules teach or suggest "said GaN semiconductor light-emitting device including a single reflective layer disposed on a surface of a substrate on which no semiconductor layer is formed," as identically recited in claim 21.

B. The JP '141 Reference

Fig. 3 of JP '141 discloses a GaN semiconductor light-emitting device including a Ti layer 2 disposed between a substrate 1 and an AlGaN buffer layer 3, which is located beneath an n-type layer 4. Fig. 4 of JP '141 discloses a GaN semiconductor light-emitting device including a Ti layer 2 disposed between a substrate 1 and an AlN buffer layer 23, which is located beneath an n-type layer 4. Fig. 5 discloses a GaN semiconductor light-emitting device including a Ti layer 2 disposed between a substrate 1 and an n-type layer 4. Fig. 6 discloses a GaN semiconductor light-emitting device including a Ti layer 42 disposed between a substrate 41 and an n-type layer 44. Fig. 7 discloses a GaN semiconductor light-emitting device including a Ti layer 42 disposed between a substrate 41 and an AlGaN layer 43, which is located beneath a p-type layer 46.

Claim 1 recites at least the features of "said GaN semiconductor light-emitting device including a single reflective layer disposed on a surface of a substrate on which no light-emitting layer is formed; and a secondary light source including a fluorescent material that comprises at least one of ZnS:Cu, Au, Al; ZnS:Cu, Al; and ZnS:Cu."

Nowhere does JP '141 teach or suggest "said GaN semiconductor light-emitting device including a single reflective layer disposed on a surface of a substrate on which no light-emitting layer is formed," as recited in claim 1. In fact, the paths along which light travels in the claimed invention and in JP '141 are completely different. In the claimed invention, the light emitted from the light emitting layer enters the substrate and is then reflected by the reflective layer. In contrast, the emitted light of JP '141 is rfelected by the TI reflective layer and does not enter the substrate.

Furthermore, nowhere does JP '141 teach or suggest "a fluorescent material that comprises at least one of ZnS:Cu, Au, Al; ZnS:Cu, Al; and ZnS:Cu," as recited in claim 1. As discussed above, the GaN semiconductor device of JP '141 only emits blue light and has no light-transmissible layer containing a fluorescent material.

Claim 21 recites at least the features of "said GaN semiconductor light-emitting device including a single reflective layer disposed on a surface of a substrate on which no light-emitting layer is formed; a second light source including a first fluorescent material that absorbs light emitted by said first light source and emits green light; and a third light source that emits red light."

For at least those reasons discussed above in regard to claim 1, nowhere does JP '141 teach or suggest "said GaN semiconductor light-emitting device including a single reflective layer disposed on a surface of a substrate on which no light-emitting layer is formed," as identically recited in claim 21.

In addition, nowhere does JP '141 teach or suggest "a second light source including a first fluorescent material that absorbs light emitted by said first light source and emits green light; and a third light source that emits red light," as recited in claim 21. As discussed above, the GaN semiconductor device of JP '141 only emits blue light and has no light-transmissible layer containing a fluorescent material.

For at least the reasons outlined above, Applicants respectfully submit that Soules and JP '141, either individually or in combination, fail to teach or suggest every feature of claims 1 and 21. Accordingly, Soules and JP '141, either individually or in combination, fail to render obvious the subject matter of claims 1 and 21, and claims 2, 3, 8, 10, 26, 27, 32, 34, 38, and 40, which depend from claims 1 and 21 under 35 U.S.C. §103(a). Withdrawal of the rejection of claims 1-3, 8, 10, 21, 26, 27, 32, 34, 38, and 40 under 35 U.S.C. §103(a) as

obvious over Soules in view of JP '141 is respectfully solicited.

C. The Butterworth Reference

Fig. 2 of Butterworth discloses a light emitting diode 200 having a lens containing a fluorescent dye (col. 2, lines 55 and 56). The blue emitting gallium nitride (GaN) die 110 is attached and wire bonded into the reflector cup lead frame 120 (col. 2, lines 3-5). Power is provided to the die 110 through leads 150 and 160 (col. 2, lines 59 and 60). LED die 110 is then over-molded with an epoxy lens 240 containing a fluorescent dye (col. 2, lines 60-62). the fluorescent dye absorbs blue light emitted from die 110 and re-emits a longer wavelength light (col. 2, lines 62 and 63). Depending on the implementation, some unabsorbed original blue light may pass through lens 240 (col. 2, lines 64 and 65).

Thus, rather than adding a separate layer of inorganic phosphor 130 as shown in Fig. 1, the preferred embodiment is to add an organic fluorescent dye to the epoxy used to mold the lens 240 as shown in Fig. 2. (col. 2, line 66 to col. 3, line 2). Moreover, a combination of dyes has been used to produce "white" light (col. 3, lines 4 and 5).

Various types of fluorescent material may be added to the lens 240, for example, Type 1261 - ZnS:Cu, Au, Al; and Type 1260 - ZnS:Cu, Al (col. 3, lines 35-55).

Claim 1 recites at least the features of "said GaN semiconductor light-emitting device including a single reflective layer disposed on a surface of a substrate on which no light-emitting layer is formed; and a secondary light source including a fluorescent material that comprises at least one of ZnS:Cu, Au, Al; ZnS:Cu, Al; and ZnS:Cu."

Claim 21 recites the identical feature of claim 1, underlined above, that is, "said GaN semiconductor light-emitting device including a single reflective layer disposed on a surface of a substrate on which no light-emitting layer is formed; a second light source including a first fluorescent material that absorbs light emitted by said first light source and emits green light; and a third light source that emits red light."

Butterworth discloses a reflector cup lead frame 120 upon which a blue emitting GaN is attached. Nowhere does Butterworth teach or suggest the structure of the blue emitting GaN die 110. In contrast, claims 1 and 21 of the claimed invention describe the GaN semiconductor light-emitting device including a single reflective layer disposed on a surface of a substrate on which no light-emitting layer is formed. Thus, the single reflective layer of

the claimed device provides greater directionality to light emitted from the light-emitting apparatus along its optical axis, because light emitted from the sides of the GaN die 110 of Butterworth will also be reflected by the reflector cup lead frame 120 in directions that deviate substantially from the optical axis of the device.

In addition, Butterworth discloses the fluorescent materials of Type 1261 - ZnS:Cu, Au, Al; and Type 1260 - ZnS:Cu, Al, but fails to teach or suggest the fluorescent material of ZnS:Cu as described in claim 1.

Butterworth fails to cure the deficiencies of Soules and JP '141. For at least the reasons outlined above, Applicants respectfully submit that Soules, JP '141, and Butterworth, either individually or in combination, fail to teach or suggest every feature of claims 1 and 21. Accordingly, Soules, JP '141, and Butterworth, either individually or in combination, fail to render obvious the subject matter of claims 1 and 21, and claims 5-7, 9, 22, and 28-33, which depend from claims 1 and 21, under 35 U.S.C. §103(a). By this Amendment, claim 4 is canceled; hence, the rejection of claim 4 is moot. Withdrawal of the rejection of claims 4-7, 9, 22, and 28-33 under 35 U.S.C. §103(a) as unpatentable over Soules and JP '141 and further in view of Butterworth is respectfully solicited.

D. The Hampden-Smith Reference

Hampden-Smith discloses that preferred sulfur-containing phosphor host materials for some display applications include the metal sulfides, particularly the Group 12 metal sulfides (e.g., ZnS and CdS) (col. 35, lines 63-67). For such metal sulfides, preferred activator ions can be selected from the rare-earth elements (e.g., La, Ce, Pm, Eu, Gd, Tb, and Yb), preferably Eu or Tb.

In addition, oxysulfides, particularly Y_2O_2S:Eu and rare-earth oxysulfides such as Gd_2O_2S:Tb and La_2O_2S:Tb can also be produced col. 36, lines 58-60 and Table 1 of col. 37).

Claim 11 recites at least the features of "said GaN semiconductor light-emitting device including a single reflective layer disposed on a surface of a substrate on which no light-emitting layer is formed; and a secondary light source including a fluorescent material that comprises at least one of ZnS:Eu and Y_2O_2S:Ce."

Hampden-Smith discloses various sulfur-containing phosphor powders, methods for making phosphor powders, and generalized devices incorporating the phosphor powders

(Abstract, lines 1 and 2). Nowhere does Hampden-Smith teach or suggest a GaN semiconductor light-emitting device including a single reflective layer disposed on a surface of a substrate on which no light-emitting layer is formed, as recited in claim 11.

As discussed above with respect to claims 1 and 21, which recite the identical feature of claim 11, underlined above, neither Soules, nor JP '141 teach or suggest the feature of "said GaN semiconductor light-emitting device including a single reflective layer disposed on a surface of a substrate on which no light-emitting layer is formed."

In addition, nowhere does Hampden-Smith teach or suggest a fluorescent material that comprises ... Y_2O_2S:Ce.

For at least the reasons outlined above, Applicants respectfully submit that Soules, JP '141, and Hampden-Smith, either individually or in combination, fail to disclose every feature of claim 11. Accordingly, Soules, JP '141, and Hampden-Smith, either individually or in combination, fail to render obvious the subject matter of claim 11 and claims 12, 13, 18, 20, and 39, which depend from claim 11, under 35 U.S.C. §103(a). Withdrawal of the rejection of claims 11-13, 18, 20, and 39 under 35 U.S.C. §103(a) as unpatentable over Soules and JP '141 in further view of Hampden-Smith is respectfully solicited.

As discussed directly above with respect to claim 11, Soules, JP '141, and Hampden-Smith do not teach or suggest the feature of "said GaN semiconductor light-emitting device including a single reflective layer disposed on a surface of a substrate on which no light-emitting layer is formed." Furthermore, as discussed with respect to the rejection of claims 4-7, 9, 22, and 28-33 under 35 U.S.C. §103(a) as unpatentable over Soules and JP '141 and further in view of Butterworth, nowhere does Butterworth teach or suggest the identical feature of claim 11, which is recited in claims 1 and 21, that is, "said GaN semiconductor light-emitting device including a single reflective layer disposed on a surface of a substrate on which no light-emitting layer is formed."

For at least the reasons outlined above, Applicants respectfully submit that Soules, JP '141, Hampden-Smith, and Butterworth, either individually or in combination, do not teach or suggest every feature of claim 11. Accordingly, Soules, JP '141, Hampden-Smith, and Butterworth, either individually or in combination, do not render obvious the subject matter of claim 11 and claims 12, 13, 18, 20, and 39, which depend from claim 11, under 35 U.S.C. §103(a). Withdrawal of the rejection of claims 11-13, 18, 20, and 39 under 35 U.S.C.

§103(a) as unpatentable over Soules, JP '141, and Hampden-Smith and in further view of Butterworth is respectfully solicited.

III. THE 35 U.S.C. §112, SECOND PARAGRAPH, REJECTIONS

The rejection of claims 12-20 under 35 U.S.C. §112, second paragraph, is rendered moot by the Preliminary Amendment filed with the Request for Continued Examination (RCE) on January 15, 2003. In claim 11 of the Preliminary Amendment, "a first fluorescent material" was amended to recite "a fluorescent material," while "a second fluorescent material" was deleted. Therefore, "said fluorescent material" of claim 12 has proper antecedent basis.

Withdrawal of the rejection of claims 12-20 under 35 U.S.C. §112, second paragraph, is respectfully solicited.

With respect to the rejection of claim 22 under 35 U.S.C. §112, second paragraph. Claim 22 is currently amended to recite, in relevant part, "said first fluorescent material comprises at least one of ZnS:Cu, Au, Al; ZnS:Cu, Al; ZnS:Cu; ~~ZnS:Mn;~~ ZnS:Eu; ~~Y_2O_2S:Eu;~~ and Y_2O_2S:Ce." Therefore, the non-green emitting phosphors of ZnS:Mn and Y_2O_2S:Eu are deleted, while the green emitting phosphor of ZnS: Cu, Al is added.

Withdrawal of the rejection of claim 22 under 35 U.S.C. §112, second paragraph, is respectfully solicited.

CONCLUSION

The Specification is currently amended to answer the Examiner's objection to a paragraph on page 14.

The dependent claim 22 is currently amended to limit the independent claim 21.

In view of the foregoing, Applicants submit that claims 1-3, 5-13, 15-22, 25-34, and 38-50, all the claims presently pending in the application, are patentably distinct over the prior art of record and are in condition for allowance. The Examiner is respectfully requested to pass the above application to issue at the earliest possible time.

Should the Examiner find the application to be other than in condition for allowance, the Examiner is requested to contact the undersigned at the local telephone number listed below to discuss any other changes deemed necessary in a telephonic or personal interview.

The Commissioner is hereby authorized to charge any deficiency in fees or to credit any overpayment in fees to Attorney's Deposit Account No. 50-0481.

Respectfully Submitted,

Date: 4/21/03

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